3 Flow and Salinity Monitoring

October 1, 2001 – December 31, 2002

Michael C. S. Eacock[1]
Nigel W.T. Quinn[2]

Grassland Bypass Project

1 Natural Resource Specialist, US Bureau of Reclamation, South-Central California Area Office, 1243 N Street, Fresno, California 93721 (559) 487-5133 ceacock@mp.usbr.gov
2 Staff Geological Scientist/Water Resources Engineer, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Building 70A-3317H, Berkeley, California 94720 (510) 486-7056 nquinn@lbl.gov

Summary

Flow and electrical conductivity (EC) were measured during the fifteen month reporting period (October 1, 2001 – December 31, 2002) to monitor the effects of the Grassland Bypass Project (GBP) on the San Luis Drain, Mud Slough, Salt Slough, and the San Joaquin River. The U.S. Geological Survey (USGS) measured flow and EC at five monitoring stations (B, D, F, G, and N). The San Luis & Delta-Mendota Water Authority (Authority) measured flow and EC at Station A. Flow at Site C is derived as the difference between flows passing Sites D and B. A new station was installed on the San Joaquin River at Fremont Ford (Site G) by the USGS.

The California Regional Water Quality Control Board, Central Valley Region (Regional Board), measured the EC of water quality samples collected at these seven sites and at six other sites where flow is not measured (C, H, J, K, L2, and M2). The San Francisco Estuary Institute compiled this information in monthly and quarterly reports.

Table 1 is a summary of sampling methods at Stations A, B, C, D, F, G, and N.

Tables 2 - 8 summarize a) monthly flows, EC measurements, and salt loads at the seven stations during the fifteen month reporting period and b) the annual averages and totals for the six years of the Project. Note that the historical salinity and load values have been updated and differ from the WY 1999 report and errata sheets.

Figure 1 shows the pattern of rainfall and discharge from the 97,000 acre Grassland Drainage Area (GDA). About 4.4 inches of rain fell on the GDA between November 2001 and April 2002, and about 2.6 inches fell during November and December 2002. Peak flow in the San Luis Drain during the fifteen month period was 70 cubic feet per second (cfs), well below the 150 cfs capacity of the SLD specified in the 2001 Use Agreement (Reclamation and SLDMWA 2001). No drain water was discharged from the Project into wetland water supply channels during the fifteen month period.

Figures 2 – 7 show the monthly flows and average EC of water that passed the seven stations.

The Regional Board has calculated factors to convert EC to TDS and these are listed in Table 1.

The method for determining flow-weighted concentrations and calculating loads of salt are explained in Regional Board, 1998 (pp. 4 - 8).

Station A - San Luis Drain near South Dos Palos, California

Grassland Bypass Project Station A	
Location	San Luis Drain Check 17, near Dos Palos, California (USGS 11262890) (Regional Board MER562)
Responsibility	San Luis & Delta-Mendota Water Authority (Summers Engineering)
Parameters	Stage, electrical conductivity, temperature
Equipment	Sharp-crested weir, stilling well with a Stevens recorder and shaft encoder, staff gauge, weir stick; electrical conductivity/temperature sensor; data logger, telephone and modem; Sigma autosampler.

Description

Station A is located near South Dos Palos, California. Its purpose is to measure the volume and quality of agricultural drainwater from the GDA as it enters the San Luis Drain.

Data Summary

Tables 2a, 2b, and 2c summarize the flow and salinity of water that passed Station A during the six years of the Project.

During the fifteen month period, the average flow that passed Station A was 32 cfs. The flow reached a maximum of 70 cfs on March 18, 2002 and again on June 17, 2002. The average EC of water that passed the site was about 4,535 microSiemens per centimeter (µS/cm), with a brief peak on October 3, 2002 of 6,250 µS/cm. The load of salt discharged from the GDA during the fifteen month period was about 126,353 tons.

Station B - San Luis Drain near Gustine, California

Grassland Bypass Project Station B	
Location	San Luis Drain, near Gustine, California (USGS 11262895, Regional Board MER535)
Responsibility	US Geological Survey (flow, EC, temp), Regional Board (EC, water quality)
Parameters	Stage, velocity, electrical conductivity, temperature
Equipment	Nitrogen bubbler pressure sensor, 2 - acoustic velocity meters, monthly current meter readings, 2 - EC/temperature sensors, data logger, telephone and modem.

Description

Station B is located about 28 miles northwest of Station A, about 2 miles from the terminus of the Drain. It is the primary site for measuring the flow and selenium load discharged from the GDA into Mud Slough. The performance of the GBP to manage flows and selenium loads is assessed at this site.

Data Summary

Tables 3a, 3b, and 3c summarize the flow and salinity of water that passed Station B during the six years of the Project.

During the fifteen month period, the average flow that passed Station B was 36 cfs. The peak flow of 69 cfs occurred on March 19, 2002 and June 18-19, 2002, one day after similar peaks at Station A.

The maximum daily EC was 5,130 µS/cm on March 30 – April 1, 2002. The flow-weighted average EC was 4,116 µS/cm. About 132,400 tons of salt were discharged from the San Luis Drain into Mud Slough during the fifteen month period.

Station C - Mud Slough (north), upstream of drainage discharge

Grassland Bypass Project Station C	
Location	Mud Slough, approximately 1/2 mile upstream of San Luis Drain terminus (Regional Board MER536)
Responsibility	Regional Board
Parameters	Electrical conductivity, temperature, pH, boron
Equipment	None. Weekly grab samples are taken here

Description

Station C is located in Mud Slough upstream from the end of the San Luis Drain. Water at this monitoring station derives primarily from managed wetlands in the North and South Grassland Water District. Data collected at this site are considered a baseline for measuring the impact of the GBP on the slough. The Regional Board collected weekly water quality samples here.

Data Summary

Tables 4a, 4b, and 4c summarize the flow and salinity of water that passed Station C during the six years of the Project. Flow was not measured at this site, but was estimated as the difference between flows passing Stations D and B.

During the fifteen month period, the average flow rate was 81 cfs. Daily flows peaked on December 23, 2002, at 491 cfs after heavy rains (Figure 1), and minimal in July and August.

About 73,640 acre-feet of water passed this site during the fifteen month period. The salinity of water at this site was measured by the Regional Board in its weekly grab samples. The average EC of water at this site was 1,690 µS/cm. The highest EC was measured on April 11, 2002 at 3,820 µS/cm. About 114,820 tons of salt were dissolved in the water that passed this site during the fifteen month period.

Station D - Mud Slough near Gustine, California, downstream from the drainage discharge

Grassland Bypass Project Station D	
Location	Mud Slough near Gustine, California (USGS 11262900) (Regional Board MER542)
Responsibility	US Geological Survey (flow, EC, temp), Regional Board (EC, water quality)
Parameters	Stage, electrical conductivity, temperature
Equipment	Nitrogen bubbler pressure transducer, electrical conductivity/temperature sensor, data logger, cellular telephone and modem.

Description

Station D is located in Mud Slough downstream from the terminus of the SLD.

Data summary

Tables 5a, 5b, and 5c summarize the daily flow and salinity of water that passed Station D during the six years of the Project.

During the fifteen month period, approximately 109,750 acre-feet of water passed this site. The GBP contributed 38% of this flow. The average flow passing Station D was 117 cfs. Peak flow was 511 cfs on December 23, 2002, following heavy rains. The average EC of water passing this site was 2,691 µS/cm. Approximately 244,920 tons of salt flowed past this site, 59 percent coming from the GBP, during the fifteen month study period.

Station F - Salt Slough at Highway 165 (Lander Avenue)

Grassland Bypass Project Station F	
Location	Salt Slough at Highway 165 near Stevinson, California (USGS 11261100) (Regional Board MER531)
Responsibility	US Geological Survey
Parameters	Stage, electrical conductivity, temperature
Equipment	Nitrogen bubbler pressure transducer, electrical conductivity/temperature sensor, data logger, cellular telephone and modem.

Description

Station F is where flow and water quality are monitored in Salt Slough. The GBP has removed the GDA's agricultural drainage water contribution to this water body. The water in Salt Slough is largely derived from wetlands in the Los Banos Wildlife Area, and the San Luis National Wildlife Refuge Complex.

Data Summary

Tables 6a, 6b, and 6c summarize the daily flow and EC of water that passed Station F during the six years of the Project.

No agricultural drainage water from the GDA was diverted into Salt Slough during the fifteen month period. The average flow of water was 153 cfs. The peak flow of 485 cfs occurred on December 22, 2002 after heavy rains. The average EC of water was 1,443 µS/cm. About 187,786 tons of salt were dissolved in water that passed this site during the fifteen month period.

Station G - San Joaquin River at Fremont Ford, California

Grassland Bypass Project Station G	
Location	San Joaquin River at Fremont Ford, California (USGS 11261500) (Regional Board MER538)
Responsibility	US Geological Survey (flow, EC, temp), Regional Board (EC, water quality)
Parameters	Stage, electrical conductivity, temperature
Equipment	Nitrogen bubbler pressure transducer, electrical conductivity/temperature sensor, data logger, GOES transmitter.

Description

Station G is a new station located along the San Joaquin River at the Highway 140 bridge, about five miles northeast of Gustine, California. It is upstream from the confluence of the river and Mud Slough. This site is used to measure the baseline flows and quality of water in the river before it receives water from the GBP.

Data Summary

Tables 7a, 7b, and 7c summarize the mean daily flow and EC of water that passed Station G during the fifteen month period. Flow was not measured here between October 1997 and December 2001. The Regional Board collected water quality samples at this site each week during this period, and the monthly average EC data are summarized in Table 7.

During the fifteen month period, the average flow that passed this site was about 222 cfs. The maximum flow of 2,100 cfs occurred on January 5, 2002. The flow-weighted average EC of water was 1,478 µS/cm.

Performance flow, EC, and temperature measurements by the USGS commenced on December 5, 2001.

Station N - San Joaquin River at Crows Landing, California

Grassland Bypass Project Station N	
Location	San Joaquin River at Crows Landing, California (USGS 11274550) (Regional Board STC504)
Responsibility	US Geological Survey (flow, EC, temp), Regional Board (EC, water quality)
Parameters	Stage, electrical conductivity, temperature
Equipment	Nitrogen bubbler pressure transducer, electrical conductivity/temperature sensor, data logger, cellular telephone and modem.

Description

Station N is located at Crows Landing on the San Joaquin River, about ten miles downstream of the tributary of the Merced River.

Data Summary

Tables 8a, 8b, and 8c summarize the mean daily flow and EC of water that passed Station N during the six years of the Project.

During the fifteen month period, the average flow that passed this site was about 760 cfs. The maximum flow of 2,290 cfs occurred on January 6, 2002. The total amount of water that passed this site was about 686,120 acre-feet. The discharge from the GBP was about five percent of this flow. The flow-weighted average EC of water that passed Station N was 1,161 µS/cm. The load of salt in the water was about 648,000 tons during the fifteen month period. The discharge from the GBP was about 21 percent of the salt load measured at this site.

Performance

EC and temperature data were lost for 87 days during the fifteen month period because of vandalism. Data were lost for fifty-one consecutive days between January 23 and March 15, 2002. The Regional Board had similar problems with its autosampler on this site between October 19, 2001 and January 25, 2002. The salt load for February 2002 was estimated using USGS flows and Regional Board daily autosampler data.

Other Monitoring Stations

The Regional Board collected weekly water quality samples at Stations J, K, L2, and M2 (Camp 13, Agatha, San Luis, and Santa Fe Canals, respectively). The purpose of these sites is to ensure that no agricultural drainage water from the GDA enters wetland supply channels in Grasslands Water District. The EC of each sample was measured in the laboratory. Flow is estimated at these locations by Grasslands Water District staff.

Table 9 summarizes monthly average EC of water that passed these stations during the fifteen month period, and annual averages for the six years of the Project. The data shows an increase in salinity as water passes through the southern portion of Grassland Water District as measured at Sites J, K, and through the northern portion of Grassland Water District at Sites L, L2, M, and M2.

References

California Regional Water Quality Control Board, Central Valley Region, February 1998. Loads of Salt, Boron, and Selenium in the Grassland Watershed and Lower San Joaquin River: October 1985 to September 1995. Volume 1: Load Calculations.

San Francisco Estuary Institute, May 1998. Grassland Bypass Project Annual Report October 1, 1996 - September 30, 1997.

San Francisco Estuary Institute, June 1999. Grassland Bypass Project Annual Report October 1, 1997 - September 30, 1998.

San Francisco Estuary Institute, November 2000. Grassland Bypass Project Annual Report October 1, 1998 - September 30, 1999. with Errata Sheets.

San Francisco Estuary Institute, February 2003. Grassland Bypass Project Annual Report October 1, 2000 - September 30, 2001

U.S. Bureau of Reclamation and the San Luis & Delta-Mendota Water Authority. September 28, 2001. Agreement for Use of the San Luis Drain. Agreement No. 01-WC-20-2075.

Table 1. Summary of Flow and Salinity Monitoring

Station	Agency	Parameter	Sample frequency	EC to TDS Factor (b)
A	SLDMWA	Flow	Continuous	
	SLDMWA	EC	Continuous	0.74
	CVRWQCB	EC	Weekly composite of daily samples	
B	USGS	Flow	Continuous	
	USGS	EC	Continuous	0.74
	CVRWQCB	EC	Daily composite samples	
C		Flow	Derived (a)	
	CVRWQCB	EC	Weekly grab	0.68
D	USGS	Flow	Continuous	
	USGS	EC	Continuous	0.69
	CVRWQCB	EC	Weekly grab	
F	USGS	Flow	Continuous	
	USGS	EC	Continuous	0.68
	CVRWQCB	EC	Weekly grab	
G	USGS	Flow	Continuous	
	USGS	EC	Continuous	0.68
	CVRWQCB	EC	Weekly grab	
N	USGS	Flow	Continuous	
	USGS	EC	Continuous	0.62
	CVRWQCB	EC	Daily composite samples	
	CVRWQCB	EC	Weekly grab	

Notes:

(a) Flow passing Station C is calculated as difference between flows at Stations D and B.

(b) CVRWQCB, 1998. Page 15; San Luis Drain factor revised 10/2000.

EC - Electrical Conductivity

TDS - Total Dissolved Solids

Table 2a. Monthly Flow and Salinity of Water Entering the San Luis Drain, (Station A), October 2001 – December 2002

	Flow		Salinity		
	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
Oct-2001	11	672	4,980	3,685	3,368
Nov-2001	13	749	4,460	3,300	3,362
Dec-2001	12	755	4,760	3,522	3,618
Jan-2002	22	1,323	4,820	3,567	6,419
Feb-2002	47	2,593	4,390	3,249	11,457
Mar-2002	52	3,182	4,630	3,426	14,826
Apr-2002	42	2,484	4,700	3,478	11,750
May-2002	42	2,588	4,430	3,278	11,538
Jun-2002	55	3,269	4,170	3,086	13,719
Jul-2002	53	3,230	3,910	2,893	12,710
Aug-2002	54	3,318	3,580	2,649	11,954
Sep-2002	28	1,658	4,350	3,219	7,258
Oct-2002	15	901	5,040	3,730	4,570
Nov-2002	15	865	4,870	3,604	4,240
Dec-2002	18	1,112	4,900	3,626	5,484
15 month average:	32		4,533	3,354	
15 month total:		28,700			126,275

Data sources: Flow and EC- San Luis & Delta-Mendota Water Authority (Summers Engineering)
Total acre-feet, TDS, and salt load - calculated

Note: EC - TDS conversion: 0.74

Table 2b. Average Flow and Salinity at Station A, Water Years 1997 – 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	52	37,786	4,477	3,313	176,433
WY 1998	61	43,550	4,625	3,423	195,263
WY 1999	42	30,470	4,821	3,567	143,705
WY 2000	40	29,350	4,478	3,314	129,368
WY 2001	37	27,005	4,634	3,429	125,394
WY 2002	36	25,822	4,432	3,279	111,981

Data sources: Grassland Bypass Project Annual Report 2000 - 2001.

Table 2c. Average Flow and Salinity at Station A, 1997 – 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	51	36,580	4,627	3,424	173,154
CY 1998	62	44,201	4,699	3,477	199,506
CY 1999	41	29,869	4,767	3,528	139,922
CY 2000	40	28,939	4,379	3,241	126,124
CY 2001	36	26,143	4,668	3,454	121,678
CY 2002	37	26,524	4,483	3,317	115,926

Data sources: Grassland Bypass Project Annual Report 2000 - 2001.

Table 3a. Monthly Flow and Salinity of Water in the San Luis Drain (Station B), October 2001 – December 2002

	Flow		Salinity		
	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
Oct-2001	18	1,100	3,879	2,870	4,294
Nov-2001	22	1,320	3,782	2,799	5,024
Dec-2001	20	1,250	4,219	3,122	5,308
Jan-2002	27	1,660	4,287	3,172	7,162
Feb-2002	49	2,730	4,314	3,192	11,853
Mar-2002	55	3,370	4,391	3,249	14,892
Apr-2002	41	2,430	4,650	3,441	11,372
May-2002	43	2,640	4,171	3,087	11,082
Jun-2002	56	3,320	3,931	2,909	13,134
Jul-2002	53	3,260	3,886	2,876	12,749
Aug-2002	55	3,410	3,474	2,571	11,922
Sep-2002	32	1,910	3,843	2,844	7,387
Oct-2002	20	1,240	4,177	3,091	5,213
Nov-2002	19	1,150	4,182	3,095	4,840
Dec-2002	22	1,360	4,556	3,371	6,236
15 month average:	35		4,116	3,046	
15 month total:		32,150			132,468

Data sources: Flow and electrical conductivity - US Geological Survey Station No. 11262895
Total acre-feet, TDS, and salt load - calculated

Note: EC - TDS conversion: 0.74

Table 3b. Average Flow and Salinity at Station B, Water Years 1997 - 2002

	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	52	37,549	4,257	3,150	167,739
WY 1998	64	45,940	4,439	3,284	205,104
WY 1999	45	32,310	4,650	3,441	149,133
WY 2000	43	31,260	4,301	3,183	134,994
WY 2001	39	28,254	4,202	3,110	120,008
WY 2002	39	28,400	4,069	3,011	116,180

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 3c. Average Flow and Salinity at Station B, Calendar Years 1997 – 2002

	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	52	37,478	4,354	3,222	169,236
CY 1998	64	46,240	4,563	3,377	208,884
CY 1999	45	32,250	4,532	3,354	146,530
CY 2000	42	30,210	4,189	3,100	128,576
CY 2001	39	28,014	4,200	3,108	119,266
CY 2002	39	28,480	4,155	3,075	117,842

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 4a. Monthly Flow and Salinity of Water in Mud Slough Upstream of Drainage Discharge (Station C), October 2001 - December 2002

	Estimated Flow (*)		Salinity		
	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
Oct-2001	106	6,529	1,224	832	7,391
Nov-2001	148	8,778	1,383	940	11,227
Dec-2001	110	6,792	1,853	1,260	11,639
Jan-2002	124	7,599	1,968	1,338	13,830
Feb-2002	100	5,549	2,177	1,480	11,172
Mar-2002	84	5,179	2,765	1,880	13,243
Apr-2002	16	950	2,383	1,620	2,094
May-2002	21	1,321	1,861	1,265	2,274
Jun-2002	16	978	1,403	954	1,269
Jul-2002	21	1,274	2,177	1,480	2,565
Aug-2002	15	892	971	660	801
Sep-2002	17	1,037	1,061	721	1,018
Oct-2002	78	4,792	1,056	718	4,680
Nov-2002	136	8,057	1,435	976	10,692
Dec-2002	226	13,877	1,627	1,106	20,880
15 month average:	81		1,690	1,149	
15 month total:		73,604			114,773

Data sources: Flow - Calculated difference between Stations B and D.
EC - California Regional Water Quality Control Board, Site MER536
Total acre-feet, TDS, and salt load - calculated

Note: EC - TDS conversion: 0.68

Table 4b. Average Flow and Salinity at Station C, Water Years 1997 - 2002

	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	129	93,381	1,300	884	99,334
WY 1998	193	136,640	1,185	806	146,403
WY 1999	96	69,050	1,427	970	90,132
WY 2000	87	63,180	1,455	990	84,197
WY 2001	90	64,617	1,696	1,153	92,674
WY 2002	65	46,878	1,769	1,203	78,521

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 4c. Average Flow and Salinity at Station C, Calendar Years 1997 - 2002

	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	122	87,972	1,380	939	103,057
CY 1998	193	137,080	1,127	766	139,962
CY 1999	92	66,490	1,457	991	89,568
CY 2000	91	65,862	1,446	983	86,603
CY 2001	84	60,874	1,778	1,209	95,993
CY 2002	71	51,505	1,740	1,183	84,517

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 5a. Monthly Flow and Salinity of Water in Mud Slough Downstream of Drainage Discharge (Station D), October 2001 - December 2002

	Flow		Salinity		
	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
Oct-2001	124	7,629	1,572	1,085	11,254
Nov-2001	170	10,098	1,660	1,145	15,730
Dec-2001	131	8,041	2,056	1,419	15,514
Jan-2002	151	9,259	2,430	1,677	21,113
Feb-2002	149	8,279	2,870	1,980	22,297
Mar-2002	139	8,549	3,430	2,367	27,517
Apr-2002	57	3,380	4,130	2,850	13,100
May-2002	64	3,961	3,480	2,401	12,935
Jun-2002	72	4,298	3,560	2,456	14,358
Jul-2002	74	4,534	3,190	2,201	13,573
Aug-2002	70	4,302	3,080	2,125	12,434
Sep-2002	50	2,947	2,840	1,960	7,854
Oct-2002	98	6,032	2,160	1,490	12,227
Nov-2002	155	9,207	1,900	1,311	16,416
Dec-2002	248	15,237	2,000	1,380	28,597
15 month average:	117		2,691	1,856	
15 month total:		105,753			244,918

Data sources: Flow and electrical conductivity - US Geological Survey Station No. 11262900
Total acre-feet, TDS, and salt load - calculated

Note: EC - TDS conversion: 0.69

Table 5b. Average Flow and Salinity at Station D, Water Years 1997 - 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	181	130,930	2,390	1,649	254,022
WY 1998	257	182,580	2,600	1,794	369,564
WY 1999	141	101,360	2,582	1,781	229,871
WY 2000	131	94,440	2,496	1,722	201,601
WY 2001	129	92,871	2,769	1,910	214,420
WY 2002	104	75,277	2,858	1,972	187,679

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 5c. Average Flow and Salinity at Station D, Calendar Years 1997 - 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	174	125,450	2,471	1,705	256,897
CY 1998	258	183,320	2,559	1,766	365,813
CY 1999	137	98,740	2,589	1,786	225,749
CY 2000	133	96,072	2,471	1,705	201,846
CY 2001	123	88,887	2,796	1,930	216,029
CY 2002	111	79,985	2,923	2,017	202,420

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 6a. Monthly Flow and Salinity of Water in Salt Slough (Station F) October 2001 - December 2002

	Flow		Salinity		
	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
Oct-2001	95	5,833	1,402	953	7,563
Nov-2001	147	8,773	1,449	985	11,756
Dec-2001	126	7,765	1,757	1,195	12,617
Jan-2002	125	7,629	2,040	1,387	14,393
Feb-2002	185	10,197	1,540	1,047	14,522
Mar-2002	274	16,770	1,730	1,176	26,830
Apr-2002	155	9,160	1,620	1,102	13,723
May-2002	128	7,797	1,460	993	10,528
Jun-2002	141	8,349	1,220	830	9,420
Jul-2002	152	9,330	1,050	714	9,060
Aug-2002	136	8,349	1,030	700	7,953
Sep-2002	83	4,921	1,220	830	5,552
Oct-2002	103	6,319	1,280	870	7,480
Nov-2002	189	11,264	1,390	945	14,480
Dec-2002	261	16,227	1,460	993	21,910
15 month average:	153		1,443	981	
15 month total:		138,683			187,786

Data sources: Flow and electrical conductivity - US Geological Survey Station No. 11361100
Total acre-feet, TDS, and salt load - calculated

Note: EC - TDS conversion: 0.68

Table 6b. Average Flow and Salinity at Station F, Water Years 1997 – 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	216	156,091	1,295	880	192,670
WY 1998	273	196,090	1,387	943	258,123
WY 1999	211	151,767	1,192	811	171,743
WY 2000	195	141,061	1,314	894	170,851
WY 2001	185	133,892	1,350	918	168,735
WY 2002	146	104,873	1,460	993	143,917

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 6c. Average Flow and Salinity at Station F, Calendar Years 1997 – 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	205	147,946	1,356	922	187,890
CY 1998	280	201,357	1,292	879	254,652
CY 1999	205	147,390	1,255	853	172,107
CY 2000	194	140,372	1,284	873	168,708
CY 2001	181	131,118	1,399	951	170,343
CY 2002	161	116,312	1,420	966	155,851

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 7a. Monthly Flow and Salinity of Water in San Joaquin River, Fremont Ford (Station G), October 2001 - December 2002

	Flow		Salinity		
	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
Oct-2001	na	na	1,710	1,163	na
Nov-2001	na	na	1,650	1,122	na
Dec-2001	185	11,360	1,481	1,007	15,559
Jan-2002	539	33,168	852	579	26,134
Feb-2002	250	13,871	1,602	1,089	20,550
Mar-2002	329	20,210	1,860	1,265	34,764
Apr-2002	189	11,260	1,945	1,323	20,254
May-2002	149	9,130	1,725	1,173	14,565
Jun-2002	150	8,920	1,400	952	11,549
Jul-2002	162	9,935	1,183	804	10,869
Aug-2002	152	9,372	1,204	819	10,435
Sep-2002	102	6,040	1,315	894	7,345
Oct-2002	107	6,661	1,502	1,021	9,252
Nov-2002	209	12,266	1,492	1,015	16,925
Dec-2002	368	22,271	1,253	852	25,807
15 month average:	222		1,478	1,005	
15 month total:		na			na

Data sources: Flow and electrical conductivity - US Geological Survey Station No. 11261500
Total acre-feet, TDS, and salt load - calculated by USBR

Notes: EC - TDS conversion: 0.68
New Station installed by USGS December 2001.
October and November EC and TDS calculated from CVRWQCB weekly grab data.

Table 7b. Average Flow and Salinity at Station G, Water Years 1997 – 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	na	na	1,047	712	na
WY 1998	na	na	703	478	na
WY 1999	na	na	1,138	774	na
WY 2000	na	na	1,321	898	na
WY 2001	na	na	1,514	1,029	na
WY 2002	221	133,266	1,494	1,016	172,025

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Note: 1997 - 2001 electrical conductivity and TDS calculated from weekly samples collected by the Regional Board.

Table 7c. Average Flow and Salinity at Station G, Calendar Years 1997 – 2002

	Average	Total	Electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	na	na	1,202	817	na
CY 1998	na	na	512	348	na
CY 1999	na	na	1,342	913	na
CY 2000	na	na	1,285	874	na
CY 2001	na	na	1,558	1,060	na
CY 2002	226	163,104	1,444	982	208,450

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 8a. Monthly Flow and Salinity of Water in the San Joaquin River at Crows Landing (Station N), October 2001 - December 2002

	Flow		Salinity			
	Average	Total	Flow-weighted electrical conductivity		Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm		mg/L	tons
Oct-2001	742	45,632	768		476	29,550
Nov-2001	990	58,918	805		499	39,992
Dec-2001	949	58,325	1,016		630	49,967
Jan-2002	1,195	73,507	945	*	586	58,572
Feb-2002	798	44,321	1,558	*	966	58,225
Mar-2002	865	53,186	1,731	*	1,073	77,629
Apr-2002	699	41,598	1,347		835	47,247
May-2002	985	57,543	818		507	39,690
Jun-2002	492	30,054	1,407		872	35,656
Jul-2002	414	25,482	1,436		890	30,855
Aug-2002	409	25,141	1,390		862	29,466
Sep-2002	340	20,256	1,205		747	20,581
Oct-2002	630	38,744	813		504	26,560
Nov-2002	820	48,671	1,072		665	43,994
Dec-2002	1,050	64,739	1,099		681	59,992
15 month average:	759		1,161		720	
15 month total:		686,117				647,975

Data sources: Flow and electrical conductivity - US Geological Survey Station No. 11274550
Total acre-feet, TDS, and salt load - calculated

Note: EC - TDS conversion: 0.62
No USGS EC data collected between January 23 and March 15, 2002 due to equipment failure.
* - CVRWQCB daily autosampler data used to replace missing USGS data.

Table 8b. Average Flow and Salinity at Station N, Water Years 1997 – 2002

	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
WY 1997	5,408	3,844,270	820	508	1,080,703
WY 1998	6,868	4,904,910	601	373	1,511,470
WY 1999	1,412	1,015,350	902	559	680,098
WY 2000	1,417	1,027,480	976	605	703,876
WY 2001	903	653,425	1,185	734	623,555
WY 2002	712	556,214	1,212	752	542,457

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 8c. Average Flow and Salinity at Station NF, Calendar Years 1997 – 2002

	Average	Total	Flow-weighted electrical conductivity	Total dissolved solids	Salt load
	cfs	acre-feet	µS/cm	mg/L	tons
CY 1997	5,063	3,590,370	975	604	1,072,468
CY 1998	7,086	5,064,280	453	281	1,516,097
CY 1999	1,206	864,520	1,017	631	664,465
CY 2000	1,460	1,059,222	905	561	689,512
CY 2001	882	638,208	1,174	728	623,841
CY 2002	725	523,242	1,235	766	528,466

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Table 9a. Electrical Conductivity of Water in Grassland Wetland Supply Channels (October 2001 - December 2002)

GBP Station	H	J	K	L	L2	M	M2
Location	San Joaquin River at Hills Ferry	Camp 13	Agatha Canal	San Luis Canal	San Luis Canal, d/s of Splits	Santa Fe Canal	Santa Fe Canal, d/s of Splits
Units	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm
Oct-2001	1,680	676	656		851		882
Nov-2001	1,610	600	622		1,257		1,038
Dec-2001	2,153	678	833		1,508		1,413
Jan-2002	1,798	656	707		1,616		1,552
Feb-2002	2,243	723	830		977		1,583
Mar-2002	2,360	983	2,380		961		2,350
Apr-2002	2,500	1,181	2,070		927		1,850
May-2002	2,223	592	544		830		1,113
Jun-2002	2,223	738	560		658		1,242
Jul-2002	1,758	439	429		852		1,125
Aug-2002	1,863	659	556		1,210		1,260
Sep-2002	1,780	722	633		819		1,074
Oct-2002	1,698	732	649		695		886
Nov-2002	1,618	653	627		1,076		n/a
Dec-2002	1,608	807	648		1,110		n/a
15 month average	1,941	723	850		1,023		1,336

Data source: Electrical conductivity calculated from weekly grab samples collected by the Regional Board

Notes: Site H averages calculated from weekly grab samples collected by the Grassland Area Farmers.

Table 9b. Average Electrical Conductivity of Water in Grassland Wetland Supply Channels, Water Years 1997 – 2002

GBP Station	H	J	K	L	L2	M	M2
Location	San Joaquin River at Hills Ferry	Camp 13	Agatha Canal	San Luis Canal	San Luis Canal, d/s of Splits	Santa Fe Canal	Santa Fe Canal, d/s of Splits
Units	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm
WY 1997	1379	835	572	934.9		933.7	
WY 1998	1,021	1,424	969	1,214		1,284	
WY 1999	1,550	522	597		738		1,302
WY 2000	na	667	583		925		1,359
WY 2001	1,965	640	714		1,190		1,281
WY 2002	2,016	721	902		1,039		1,373

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Notes: Site H averages for 1997 - 1999 were calculated from weekly grab samples collected by the Regional Board.
Site H 2001 - 2002 averages calculated from weekly grab samples collected by the Grassland Area Farmers.

Table 9c. Average Electrical Conductivity of Water in Grassland Wetland Supply Channels, Calendar Years 1997 – 2002

GBP Station	H	J	K	L	L2	M	M2
Location	San Joaquin River at Hills Ferry	Camp 13	Agatha Canal	San Luis Canal	San Luis Canal, d/s of Splits	Santa Fe Canal	Santa Fe Canal, d/s of Splits
Units	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm	µS/cm
CY 1997	1,520	1,040	615	997		1,079	
CY 1998	852	1,168	879	1,165		1,283	
CY 1999	1,673	630	686		829		1,356
CY 2000	na	632	558		1,168		1,276
CY 2001	1,927	657	751		1,064		1,331
CY 2002	1,973	740	886		978		1,404

Data source: Grassland Bypass Project Annual Report 2000 - 2001.

Notes: Site H averages for 1997 - 1999 were calculated from weekly grab samples collected by the Regional Board.
Site H 2001 - 2002 averages calculated from weekly grab samples collected by the Grassland Area Farmers.

Figure 1. Daily Rainfall and Discharge from the Grassland Bypass Project, October 2001 - December 2002